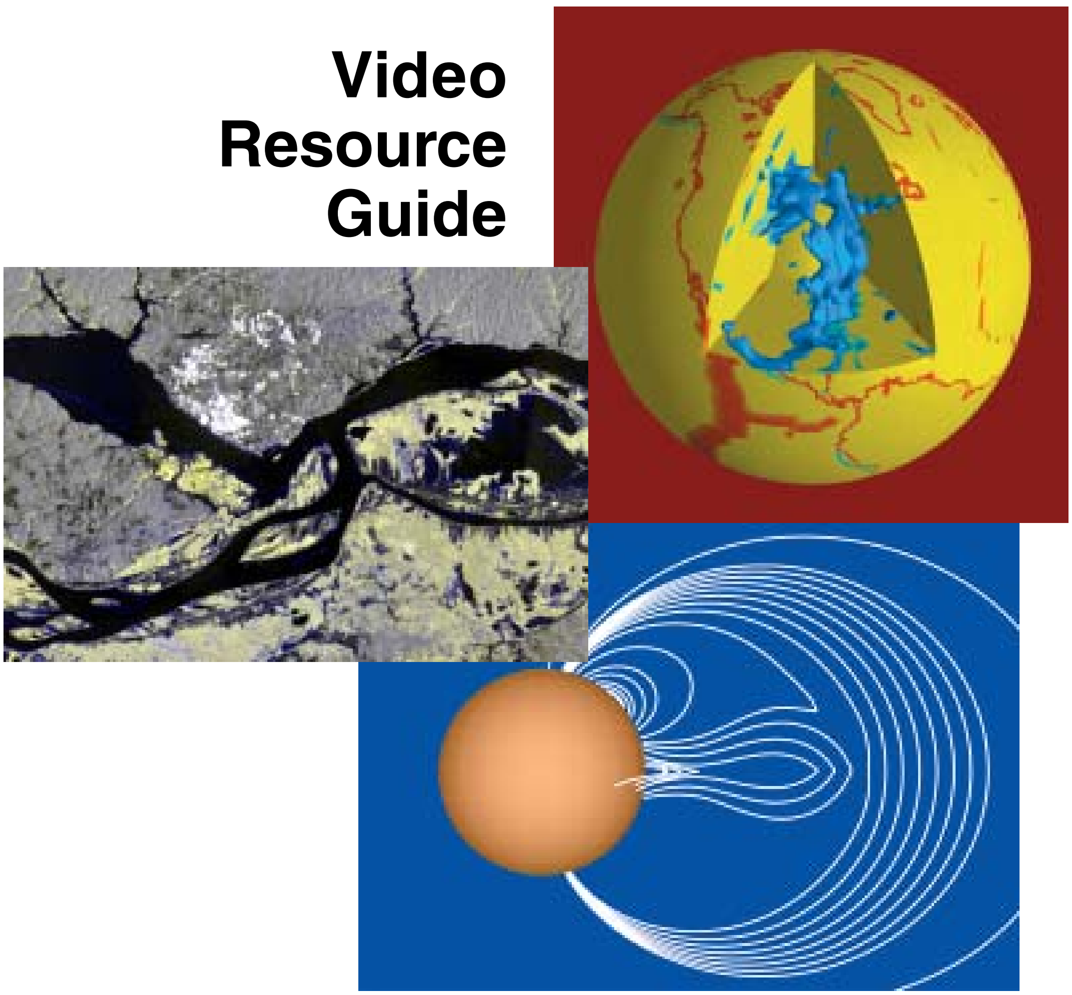
National Aeronautics and
Space Administration

Educational Product	
Educators and Students	Grades 9–12

EV-2002-09-001

Journeys through Earth and Space

Video Resource Guide



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Description

Why are the Rocky Mountains so far inland? How do we preserve the changing Amazon rainforest? When will the Sun fling parts of itself towards Earth?

The video magazine “Journeys through Earth and Space” follows three NASA Computational Technologies Project (formerly known as the Earth and Space Sciences Project) research teams tackling these questions with supercomputers.

“Journeys” begins with a short introduction that explains what supercomputers do and how scientists tap their power to recreate the universe mathematically. The three stories then show how the teams are using their software to better understand, and perhaps one day predict, nature.

As with a television documentary, researcher interviews mix with scientific imagery (observations, visualizations, animations), and stunning nature footage.

“Journeys” is available in video format and is also on the World Wide Web, along with this Video Resource Guide, at:

http://ct.gsfc.nasa.gov/journeys

Video Contents

Segment	Run Time
Introduction	1:22
A Rocky Paradox	4:40
Mapping the Amazon	6:01
The Violent Sun	4:56
Credits	1:27
Total	18:26

Overview

Subjects

Supercomputers, simulation, modeling, plate tectonics, Rocky Mountains, seismology, Amazon rainforest, radar imagery, satellite mapping, data processing, scientific visualization, global warming, solar storms, coronal mass ejections, magnetic fields

Background

The Earth, its relationship to the Sun and Solar System, and the universe in its totality are the domain of the Computational Technologies (CT) Project, formerly known as the Earth and Space Sciences (ESS) Project. The project employs advanced computers to further our understanding of and ability to predict the dynamically interacting physical, chemical, and biological processes that drive these systems. Its ultimate goal is building an assortment of computer-simulated models that combine complex Earth and space science disciplines.

High-resolution, multidisciplinary models are crucial for their predictive value and for their capacity to estimate beyond what we can measure and observe directly. For example, we cannot “see” the beginnings of the universe or even the birth of our own planet, but simulation can provide insight into how they evolved by filling in the gaps left by telescopes or geological records.

Much of the Earth and space sciences relies on data collected by a panoply of satellites, telescopes, and other instruments. There are already massive volumes of data on hand. For instance, more than one trillion bytes of data are gathered, processed, and archived by NASA’s Earth Observing System satellites each day. The CT Project is therefore engaged in developing innovative methods for analysis, ranging from visualization and virtual reality to “intelligent” information systems and assimilating data into models.

“Journeys through Earth and Space” follows three CT Project investigation teams. Two teams use simulations in their research. The scientists in “A Rocky Paradox” reconstruct the tectonic plate movements that formed the Rocky Mountains millions of years ago. Moving to the present—and ultimately the future—“The Violent Sun” researchers simulate the magnetic phenomena that fuel potentially destructive solar storms. Meanwhile, the team “Mapping the Amazon” processes satellite data into wall-sized mosaics that capture two seasons of the entire rainforest in a single view.

For more information about the CT Project, visit:

http://ct.gsfc.nasa.gov

Classroom Activities

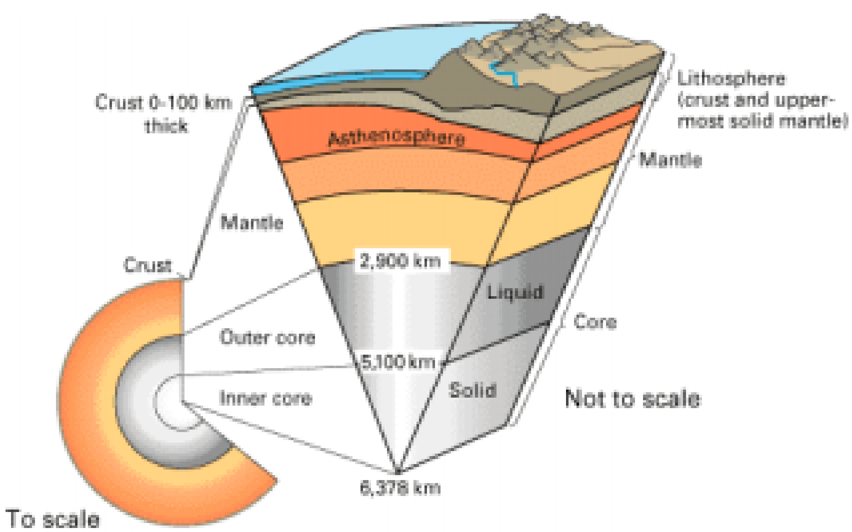
Introduction and A Rocky Paradox: Plate Tectonics/Mountain Building

Subjects

Supercomputers, simulation, modeling, plate tectonics, Rocky Mountains, seismology

Background

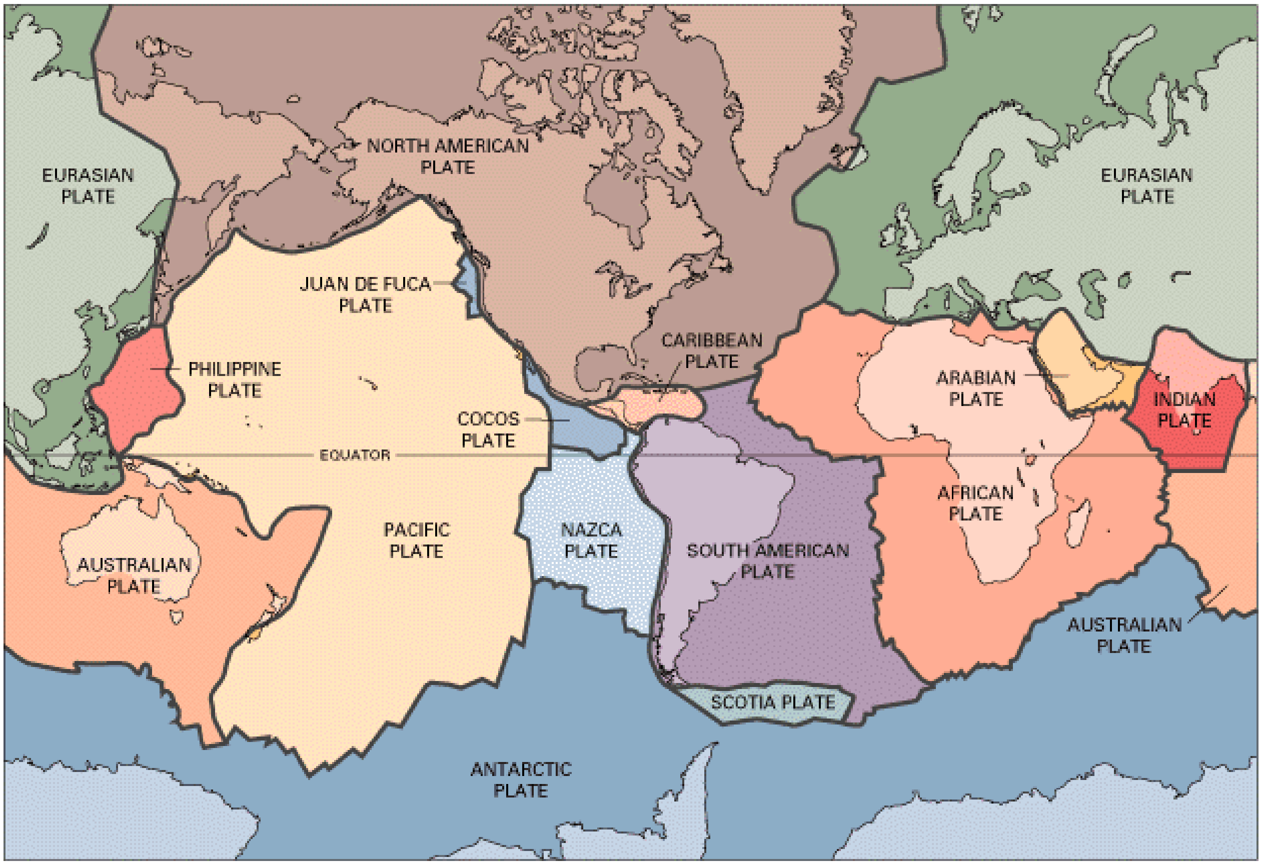
The solid Earth consists of several layers. The outermost layer is the solid crust on which we walk. The crust is about 35 kilometers thick under the continents. The crust is the thinnest layer of the Earth. The lithosphere below the crust is solid and consists mainly of materials more dense than crustal rocks. The total thickness of the lithosphere is about 100 kilometers. The mantle is a very thick shell with a thickness of 2,900 kilometers. The mantle behaves like something hard or solid and is the thickest layer. The outer core is about 2,200 kilometers thick. The outer core behaves as a liquid. The inner core behaves as a solid and is 1,200 kilometers thick. Temperatures increase as you go deeper into the Earth.



Earth's inner furnace
Source: http://observe.arc.nasa.gov/nasa/earth/tectonics/Tectonics2_and_a_quarter.html

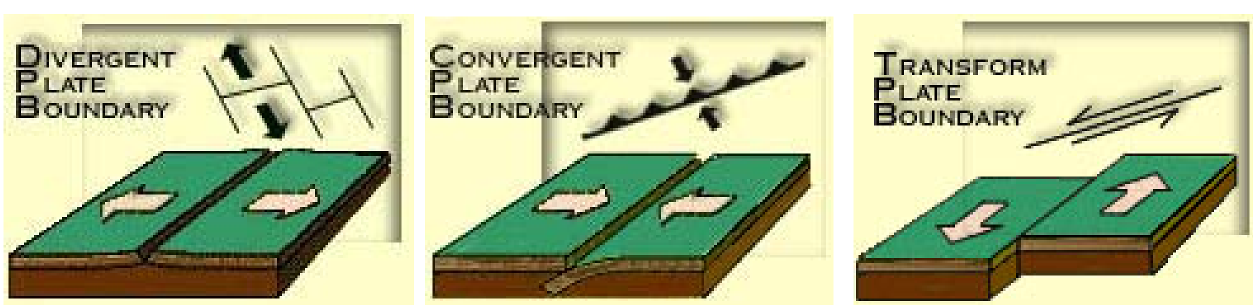
A tectonic plate is a massive section of the Earth's crust (lithosphere) that "rides" upon the asthenosphere, a hot, semiplastic layer of the planet. Plates are moved on the asthenosphere by convection currents. These plates move independently, sometimes colliding, sometimes sliding against each other. The Earth's surface is broken into 10 to 12 major plates and many smaller minor plates. These plates, each about 100 kilometers (60 miles) thick, move relative to one another an average of a few centimeters a year.

Plate tectonics is the branch of science that deals with the process by which rigid plates move across hot, more deformable material. It has helped to explain much in global-scale geology, including the formation of mountains and the distribution of earthquakes and volcanoes.



Major tectonic plates of the world
Source: http://geology.er.usgs.gov/eastern/plates.html

Three types of movement are recognized at the boundaries between plates: convergent, divergent, and transform-fault.



Three types of faults
Source: http://observe.arc.nasa.gov/nasa/earth/tectonics/Tectonics3.html

A divergent fault is a boundary between two plates where the plates are moving away from each other. Magma from deep within the Earth pushes its way up, forcing the plates apart. As two plates pull apart, rock below partially melts to produce magma that rises and fills the gap. This process can create seafloor spreading.

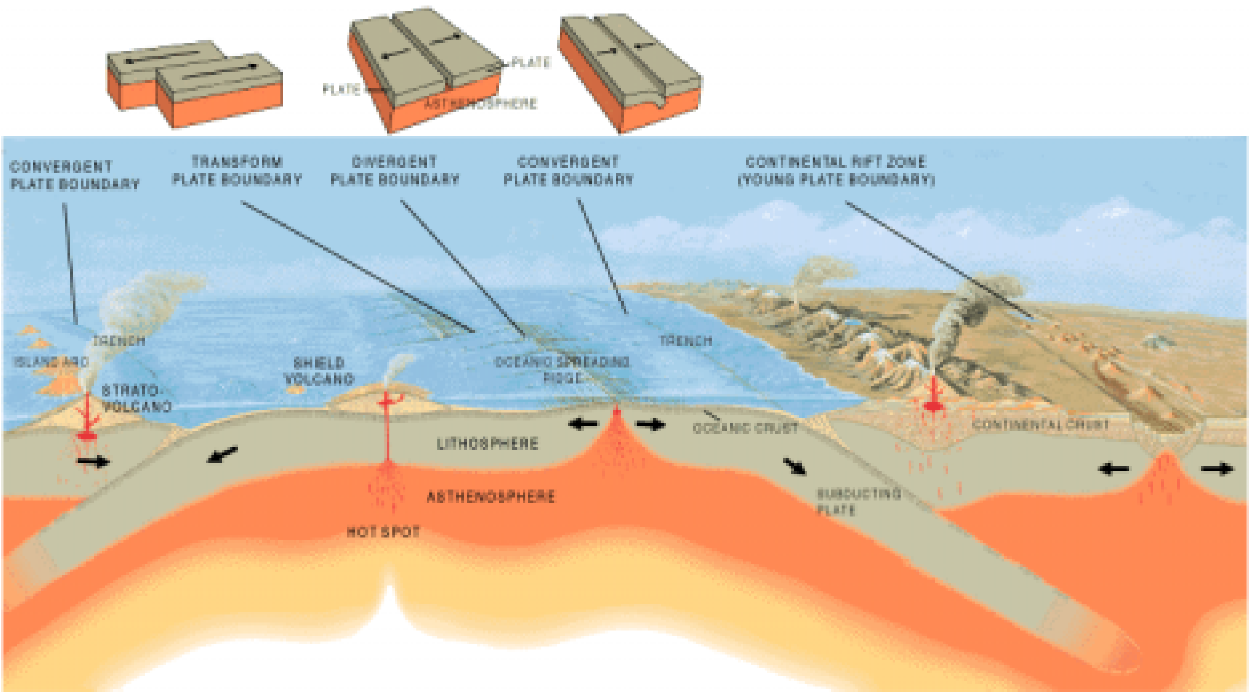


Plate boundary interactions
Source: http://pubs.usgs.gov/publications/text/Vigil.html

A boundary where two plates collide is known as a convergent fault. There are three types of convergent faults: Oceanic crust colliding with oceanic crust (O-O), oceanic crust colliding with continental crust (O-C), and continental crust colliding with continental crust (C-C). At convergent boundaries, plates move toward each other and collide. Where an oceanic plate collides with a continental plate, the more dense oceanic plate tips down and slides beneath the continental plate forming a deep ocean trench (a long, narrow, deep basin.) An example of this type of movement, called subduction, occurs at the boundary between the oceanic Nazca Plate and the continental South American Plate. Where continental plates collide, they form major mountain systems such as the Himalayas.

A transform fault occurs where two plates are sliding past each other. These boundaries are often hazardous areas to live in, since they are prone to earthquakes. Earthquakes can happen at these faults when the plates “stick” together, causing a buildup of pressure. When the pressure becomes too much, the plate can slip, releasing a lot of energy. This energy can cause an earthquake. The San Andreas Fault zone is an example of this type of boundary.

The processes that produce mountain belts are called orogenesis. Mountain belts are typically formed by plate tectonic activity, specifically continental collision. Orogeny is the variety of processes that result in mountain formation.

Lesson Plan

Objectives

Students will

Describe and draw Earth's geological layers from the inner core to the outer continental crust.
Explain the process of orogenesis using drawings and simulations from plate tectonics theory.
Use a bar graph to describe the relative thickness of each of the Earth's geologic layers.
Create a clay model of divergent, convergent, and transform fault plate boundaries.

Engage:

1. Locate and display pictures of Nepal and its people (many are available online).
2. Scenario: Consider that you are a citizen of Nepal. Scientists tell you that your country will "cease to exist" physically and literally in 10 million years. What can this mean? Can this be true, and if so how can it be prevented? How can you or scientists explain this eventual disappearance of your homeland? What tangible evidence can support this claim?
3. Students can work in groups of three to four to discuss the real-world problem. They can use any resources available to discern plausible answers. One Internet source is: http://www.pbs.org/wgbh/nova/everest/earth/birth.html
4. Follow up with whole-group sharing. Have students make connections between the dynamic changing Earth and its effect upon human life.

Explore:

1. Have students use the Pre-viewing Activities to review and access prior knowledge. Review the vocabulary.
2. Introduce the Video Viewing Questions. Ask students to complete the questions while watching the video and check their answers with a partner after viewing.
3. Show the video "Journeys through Earth and Space," Introduction and A Rocky Paradox.
4. Discuss controversial answers to the Video Viewing Questions.
5. Have students read the Background for this story. Students will complete Activities 1, 2, 3, and 4. Activities 3 and 4, which model the three types of fault boundaries, may be done as a demonstration or in groups.
6. Have students complete Activity 5.

Explain:
Students will apply knowledge to answer the following questions:
1. What is the energy source that moves the Earth's plates? Is this an example of convection, conduction, radiation, or a combination of these? Explain.
2. Why does the Earth's inner core (4300 degrees C) have solid properties while the cooler outer core (3700 degrees C) is liquid?
3. What is the Mohorovicic Discontinuity, and why is it important to us in understanding the composition of the Earth?
4. Respond to Analysis Questions in Activity 5.

Evaluate:
Replay the video, "Journey through Earth and Space," A Rocky Paradox.
Students will write a one- to two-page essay describing in detail: "How did the Rocky mountains form and why are they so far inland from the Pacific Coast of the United States?" Do you think the Rocky Mountains have completed their formation? Defend your answer.

Extend: Technology
Use the following Web site:
Quakes and Plates
http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/trl/inv1-1.html
Students can complete an online activity that will show how tectonic plate movement is related to regions of earthquakes.

Activity Reading Level: Flesch-Kincaid: 7.5

National Standards (Science Content)
Grades 9-12

Scientific Inquiry-Content Standard A:
Abilities Necessary to do Scientific Inquiry
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.

Earth and Space Science-Content Standard D:
Energy in the Earth System
- The outward transfer of Earth's internal heat drives convection circulation in the mantle that propels the plates comprising Earth's surface across the face of the globe.

The Origin and Evolution of the Earth System
- Interactions among the solid Earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the Earth system.

Science and Technology-Content Standard E:

Understandings about Science and Technology

- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.
- Science often advances with the introduction of new technologies.

Science in Personal and Social Perspectives-Content Standard F:

Natural and Human-Induced Hazards

- Normal adjustments of Earth may be hazardous for humans.

History and Nature of Science-Content Standard G:

Nature of Scientific Knowledge

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied.
- Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available.

Additional References

On the Move: Continental Drift and Plate Tectonics
http://kids.earth.nasa.gov/archive/pangaea/

Plate Tectonics
http://scign.jpl.nasa.gov/learn/plate.htm

Plate Tectonics/Plate Types
http://observe.arc.nasa.gov/nasa/earth/tectonics/Tectonics1.html

What on Earth is Plate Tectonics
http://wrgis.wr.usgs.gov/docs/parks/pltec/pltec1.html

Major Tectonic Plates of the World
http://geology.er.usgs.gov/eastern/plates.html

Activities and Teaching Suggestions for Plate Tectonics
http://www.volcanoworld.org/vwdocs/vwlessons/plate_tectonics/part1.html

Printable World Map.
http://www.abcteach.com/Maps/world.htm

NASA Observatorium Teacher's Guides: Plate Tectonics
http://observe.arc.nasa.gov/nasa/education/teach_guide/tectonics.html

Geology: Plate Tectonics
http://www.ucmp.berkeley.edu/geology/tectonics.html

Plate Tectonics: Looking at Our Ever-Changing Planet
http://www.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/earth.htm

Plate T-48: Himalayan Front and Tibetan Plateau
http://daac.gsfc.nasa.gov/DAAC_DOCS/geomorphology/GEO_2/GEO_PLATE_T-48.HTML

Plate T-11: Appalachian Mountains
http://daac.gsfc.nasa.gov/DAAC_DOCS/geomorphology/GEO_2/GEO_PLATE_T-11.HTML

Credits

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Introduction and A Rocky Paradox: Plate Tectonics/Mountain Building

Pre-viewing Activities

Questions

What are the geological layers of the Earth?

Where is the Earth's mantle? Draw an illustration to depict the Earth's layers.

The Rocky Mountains are 1,500 kilometers (1,000 miles) inland from the Pacific coast. How do you suppose they formed so far inland?

How do you think a computer could help answer this question?

Vocabulary to Know

Convergent Plate Boundaries
Core (Inner and Outer)
Crust (Continental and Oceanic)
Divergent Plate Boundaries
Lithosphere
Mantle
Mohorovicic Discontinuity
Plate Tectonics
Transformational Plate Boundaries

Video Viewing Questions

1. What is NASA using to tackle questions such as the inland position of the Rocky Mountains?

2. Two things supercomputers can do include:
   a. ___________________________
   b. ___________________________

3. What is ESS? How is it different from Earth Science?

4. Describe the Earth's mantle.

5. What forms and drives tectonic plates?

6. How far inland are the Rocky Mountains from the Pacific coast of the U.S.?

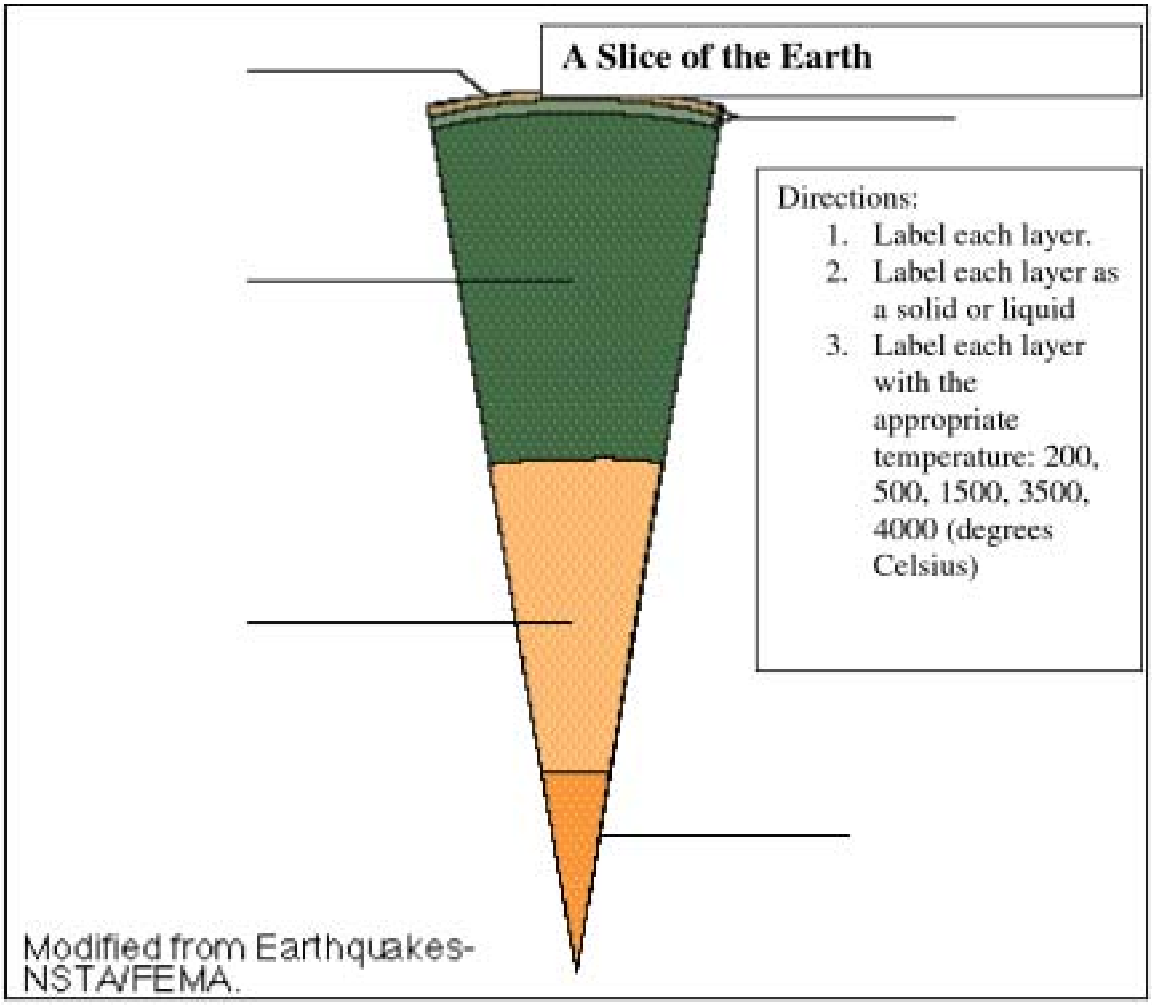
7. Which tectonic plates were involved in the formation of the Rocky Mountains?

8. What types of plates were these: convergent, divergent, or transformational? How do you know that?

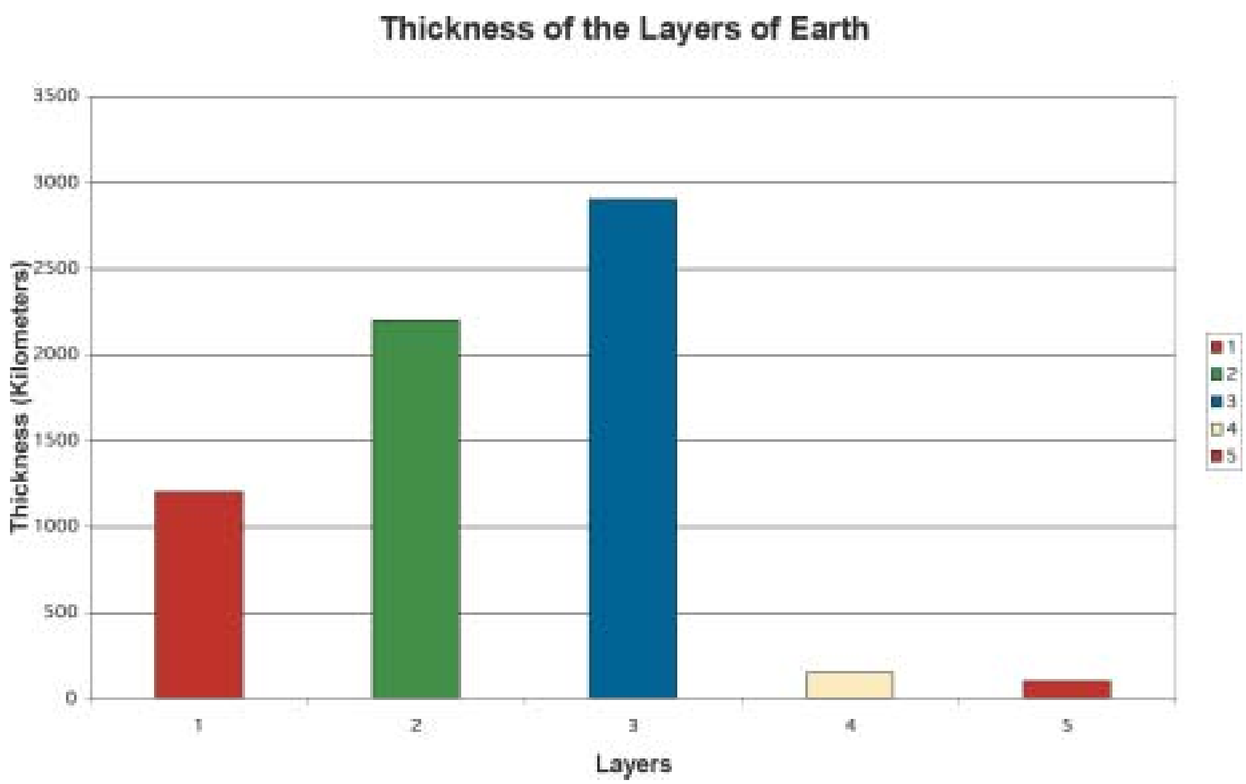
9. What caused the crust to "bob up" or upwell?

Introduction and A Rocky Paradox: Plate Tectonics/Mountain Building

Activity 1: A Slice of the Earth



Activity 2: Graph Interpretation



1. Match each bar with the appropriate layer. Choose from the list below.
______ Crust
______ Inner core
______ Lithosphere
______ Mantle
______ Outer core

2. How thick is each layer (in kilometers)?
______ Inner core
______ Outer core
______ Mantle
______ Lithosphere
______ Crust

3. What have you learned about the thickness of the layers of Earth? Summarize your findings in complete sentences.

Activity 3: Faults

Transform fault

You can simulate a transform fault by placing your hands side-by-side and sliding one forward. Each hand represents a tectonic plate.

1. Describe in your own words what happens in a transform fault. Give an example of this type of a plate boundary.

Divergent fault

Use your hands again to simulate a divergent fault. Just place your hands together and then separate one hand away from the other (left and right).

2. Describe in your own words what happens in a divergent fault.

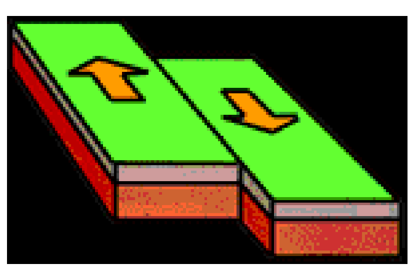
Convergent fault

Use your hands once more to simulate a convergent fault. Place your hands side-by-side. Now push one hand against the other. Allow them to push together and rise up in the center where they touch.

3. What does this uprising represent in terms of geology and plate tectonics?
4. Describe in your own words what happens in a convergent fault.

Activity 4: Clay Modeling

Use three different colors of modeling clay to create models of each type of fault: transform, divergent, and convergent. Models should look something like this example of a transform fault. Why are there three layers represented? Are there ALWAYS three layers involved in plate movement? Explain.



Activity 5: Mapping

1. Read the background material.
2. Use an atlas world relief map or an Internet site to find and name the major mountain systems. Identify and list at least eight of these.

Major Mountain Systems

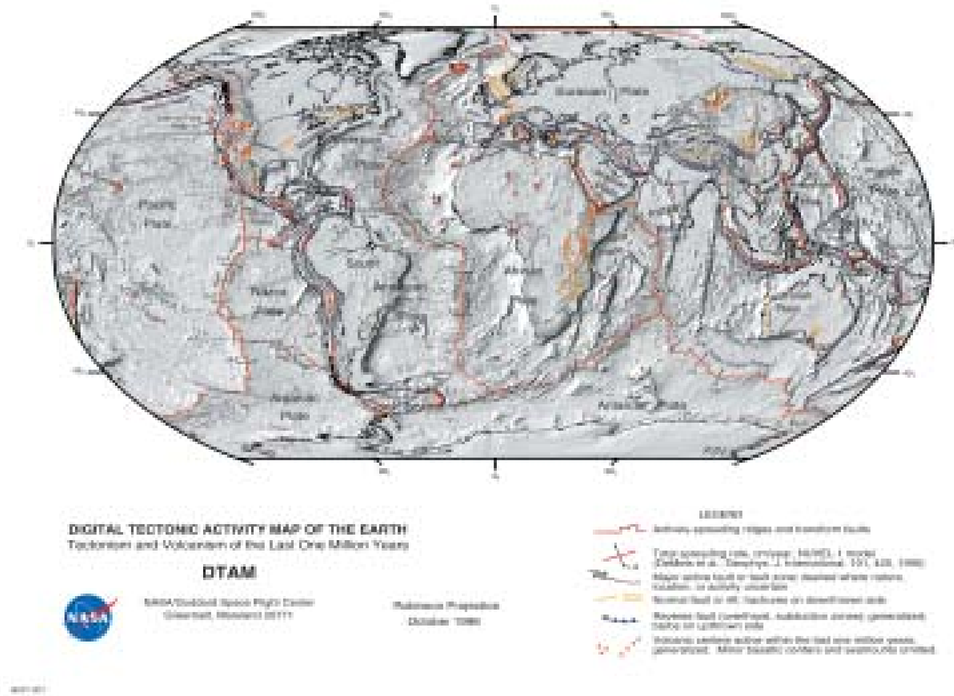
a.
b.
c.
d.
e.
f.
g.
h.

3. Use a sheet of acetate (transparency film) to trace the major tectonic plates of the world. Make sure that this is the same size as a world map you will use in the next step of this activity.
4. Overlay a geophysical or political map of the world with the tectonic plates tracing.
5. Label the plate boundaries on the overlay in the following way:

D–divergent
T–transform
C–convergent
To convergent add:
OO–oceanic with oceanic (your label should look like this, C-OO)
OC–oceanic with continental crust
CC–continental crust with continental crust.

Analysis Questions (Refer to the previous USGS map and the following NASA map.)

1. Name four major mountain ranges that might have been formed by colliding plates.
2. Using the atlas, locate the Zagros Mountains in southern Iran, where the Arabian Plate is impacting the Iranian Plate. Sketch and describe what is happening.
3. Which plate is forming the Andes Mountains on the west side of South America?
4. What plates were involved in forming the Rocky Mountains?
5. Why are the Rocky Mountains so far inland? Describe what happened.



Digital tectonic activity map of the Earth
Source: http://denali.gsfc.nasa.gov/dtam/dtam/

Introduction and A Rocky Paradox: Plate Tectonics/Mountain Building

Educators' Answer Key

Pre-viewing Activities

Questions

The three basic Earth layers are the crust, mantle, and core. (The Background material adds the lithosphere between the crust and mantle and divides the core into the outer core and the inner core.)

The mantle is the middle layer of the Earth. A drawing of concentric circles labeled with crust, mantle, and core might work well at this stage, depending on what the students have learned so far.

Although students would not be aware of it before watching the video or learning from another source, the tectonic plate that formed the Rocky Mountains did not sink until it had traveled 1,500 kilometers from the Pacific coast.

A computer can help answer the question by simulating the geological processes in detail.

Video Viewing Questions

1. Supercomputers
2. Process observations into a motion picture, solve equations that describe realities seen and unseen.
3. Earth and Space Sciences. It is different because it includes space phenomena such as the Sun.
4. The mantle is the middle layer of the Earth.
5. Tectonic plates are formed when rock cools off at the top of the mantle. The plates are driven by the flow of rock (motions) in the mantle.
6. 1,500 kilometers, or 1,000 miles
7. Farallon Plate and North American Plate
8. Convergent. The plates came together.
9. The Farallon Plate settling to the bottom of the mantle.

Additional background on Video Viewing Question 9: As the Farallon Plate moved eastward, the North American Plate moved westward above it. The lower crust of the North American Plate was relatively soft, and as this plate moved westward some of the lower crust tended to lag behind and pile up in front of where the Farallon Plate was sinking (subducting). There was a significant thickening of the crust in this region. Eventually, plate motion in the Pacific Ocean changed so that the Farallon Plate ceased to grow anymore, and the plate completely sank into the mantle. This subduction caused the thickened crust to bob up like a cork to produce the Rocky Mountains.

Activity 1: A Slice of the Earth

From top to bottom, the labels, matter states, and temperatures are as follows:

Crust	Solid	200 degrees C
Lithosphere	Solid	500 degrees C
Mantle	Solid	1500 degrees C
Outer core	Liquid	3500 degrees C
Inner core	Solid	4000 degrees C

Activity 2: Graph Interpretation

1. 5 = Crust, 1 = Inner core, 4 = Lithosphere, 3 = Mantle, 2 = Outer core

2. 1,200 km = Inner core, 2,200 km = Outer core, 2,900 km = Mantle, 100 km = Lithosphere, 35 km = Crust

Activity 5: Mapping

2. Major Mountain Systems

Alps (Europe)
Andes Mountains (South America)
Appalachian Mountains (North America)
Atlas Mountains (Africa)
Brazilian Highlands (South America)
Carpathian Mountains (Europe)
Cascade Range (North America)
Great Dividing Range (Australia)
Himalaya Mountains (Asia)
Rocky Mountains (North America)
Tian Shan (Asia)
Transantarctic Mountains (Antarctica)
Ural Mountains (Asia, Europe)
Zagros Mountains (Asia)

Analysis Questions

1. All of the Major Mountain Systems listed above qualify, plus chains such as the Sierra Nevada (North America) that formed when the Farallon Plate first sank beneath the North American Plate.
2. The Arabian Plate is colliding with the Iranian Plate, pushing the Zagros Mountains slowly upward.
3. Nazca Plate
4. Farallon Plate and North American Plate
5. The Rocky Mountains are so far inland because the Farallon Plate scraped along the bottom of the North American Plate for 1,500 kilometers before sinking to the bottom of the mantle.

Classroom Activities

Mapping the Amazon: Clearcutting in the Forest

Subjects

Amazon rainforest, radar imagery, satellite mapping, data processing, scientific visualization, global warming

Background

Deforestation and clearcutting in parts of the world have become almost epidemic. This is the subject of great environmental concern. Habitat destruction threatens to drastically reduce biodiversity worldwide. Of the current species of living organisms, more than 50 percent of all species reside in the tropical rainforests. Estimates reveal that at the current rate of deforestation, more than 100 species are being lost daily worldwide. Some of those organisms might have provided cures for debilitating or fatal diseases.

Native Indians walking through recently burnt rainforest.
Source: http://www.rainforests.net/pictures.htm

Additionally, tropical rainforest deforestation affects worldwide climate. Deforestation reduces Earth's capacity to transform atmospheric carbon dioxide into plant matter via photosynthesis and interferes with the water cycle's evapotranspiration and evaporation ratios. The result is increasing solar energy reaching the Earth's surface and air above it, which causes elevated temperatures. These processes may contribute to global warming.

Tropical rainforest deforestation to provide open land for farming and other development is currently a hot topic among environmentalists, politicians, and private citizens. Topping the list of concerns is the future of the vast "jungles" of the Brazilian Amazon, which grade into savannahs at their edges. Selling land to private farmers or large commercial logging companies is providing capital to countries whose debt is high. Farmers are provided with a means to feed their families. Yet the nutrient-poor soil of the rainforests is depleted within 2 or 3 years, requiring the use of fertilizer and pesticides, which are expensive and run off into water supplies, creating contamination.

It is clear to see that this issue is complicated and has numerous components. Not debated is the reality that we must continue to monitor closely the destruction and rebuilding of the tropical rainforests. This cannot be done effectively from the land or even from aerial views of the land. Satellites are providing new windows on our world from space.

One use of satellite images such as Landsat is to show the clearcutting that has taken place in a specific area and the forest regrowth that is occurring. "Clearcutting" means that all of the trees in an area are cut, not just selected trees. Might there be better alternatives that could result in improved quality of life for the citizens of rainforest countries while protecting valuable natural resources?

Lesson Plan

Objectives:

Students will

Describe the processes and impacts upon humans and the environment of deforestation of the tropical rainforests.
Compare and contrast deforestation techniques including slash and burn, clearcutting, selective deforestation, and shade agriculture.
Use a graph to describe patterns in Brazilian rainforest deforestation from 1975 to the present using NASA satellite data.
Prioritize and defend positions on the importance of global environmental concerns versus individual human need of Brazilian citizens in determining how much of the Amazon rainforest is "cogent" to destroy in order to build farmland and roads.

Engage:

Locate and display pictures of Brazil, its rainforest, and its people (many pictures are available on the Internet). Two are shared from the Web site noted below:

The Transamazonian highway near Altimira, Brazil, stretches through virgin rainforest.
Source: http://www.rainforests.net/pictures.htm

A satellite view of the same area a few years later reveals an advancing wave of deforestation.
Lots are parceled out to farmers along perpendicular access roads.
Source: http://www.rainforests.net/pictures.htm

Scenario

Consider that you are Miguel Diego, a poor Brazilian farmer. You have a wife and six children. You have purchased Amazon rainforest property and wish to burn off the vegetation in order to create new farmland. You realize that it will soon cost you $300 per hectare to apply necessary fertilizer and pesticides to your nutrient-poor deforested land, but you must quickly create income for your family.

As you prepare to purchase items for your farmland, Mr. Dally, a scientist and environmentalist who works for the Save Our World From People Foundation, confronts you. He reminds you that you are going to be destroying valuable vegetation, which is home to as many as 300 species of trees per hectare, not to mention the millions of species of living plants, animals, microorganisms, future medicinal products, etc., that you will soon thoughtlessly destroy. How can you do this to nature's treasures? You are also contributing to global warming by interfering with the global carbon balance. Did you not know that slash and burn deforestation releases 50 percent of the carbon stored in the tree trunks? Besides, the rain will wash away the few nutrients contained in the soil and your land will be nutrient-starved in just 2 to 3 years. Will you simply buy and burn more land then?

You note angrily that this well-meaning American probably does not have an annual income of only $6,400/person, as is the case in your country (World Bank–1998). Your first priority is to feed your family. Can he tell you a better way to do this in your homeland?

What would you do if you were Mr. Diego? Should it be the right of the people in that country to burn down as much rainforest as necessary to meet human needs? Can you think of any alternative solutions?

Students can work in groups of three to four to discuss the real-world problem. They can use any resources available to discern plausible answers. Two Internet sources are
http://ublib.buffalo.edu/libraries/projects/cases/amazon.html
http://www.bsrsi.msu.edu/rfrc/deforestation.html

Explore:

1. Have students complete the Pre-viewing Activities. Review the vocabulary.
2. Show the video "Journeys through Earth and Space," Mapping the Amazon.
3. Students will complete the Viewing Questions.
4. Discuss answers to the Video Viewing questions.
5. Read the Background on Clearcutting in the Forest.
6. Students will complete:

Activity 1

NASA Investigation. Go to the following NASA site:

Get into the Environment with Landsat
http://edmall.gsfc.nasa.gov/99invest.Site/LANDSAT/land.abstract.html

Read the background and complete Lesson 1.

Activity 2

Using the images of Rondônia, have students compare the satellite images from 1975, 1986, and 1992. They have already answered questions about these in Lesson 1 above. They will now be asked to use mathematical computations to compare the patterns of crosscutting and deforestation during this 17-year span.
Source: http://edcwww.cr.usgs.gov/earthshots/slow/Rondonia/Rondonia

Explain:
Answer discussion questions in Lesson 1 (NASA lesson).

Evaluate:
1. Students defend a debate position citing research, cost/benefit data, environmental predictions, and human benefit/suffering regarding deforestation of the tropical rainforests.

TOPIC: The IO-ME Lumber Company has proposed to purchase 5 square kilometers of Amazon rainforest land in Brazil for the obvious purpose of cutting and selling lumber. The company representatives have met with the Brazilian government officials, who realize that the income from this sale will help lower the sizable national debt and provide programs for the indigent citizens of that company. As a DEBATE TEAM you will assume one of the following roles:

1. The IO-ME Lumber Company team dispatched to make and seal the deal.
2. The Save Our Earth environmental protection group, who notes that if the present rate of rainforest destruction is not halted, then between 2012 and 2016 the virgin rainforests land area will drop below the critical built-in natural safeguard threshold of 10 percent with its 50 percent species remaining. Furthermore, carbon stored in trees will critically alter the greenhouse effect and contribute to global warming. Who really owns this Earth anyway? Is it our right to destroy nature and humankind?

All students will do research to find information relevant to the debate topics. Audience participants will prepare questions to ask each debate team. They will then use a debate team note sheet to take pertinent notes during the debate. A scoring rubric can be developed if the teacher so chooses. Each student will VOTE for the outcome based upon the number of relevant, appropriate notes taken on each column of the debate notes sheet. [Student copy provided at the end of this lesson].

2. Students submit a two-page written essay defending their debate position and listing two specific things they can do to help limit rainforest deforestation.

Extend: Technology
1. Explore Lesson 2 (from NASA Landsat lesson above, and make connections between flooding with El Niño and possible flood effects from rainforest deforestation.
2. Use NIH Image software to calculate percentages of deforestation using Rondônia satellite images in previous lesson.
3. Studying Earth's Environment from Space
http://see.gsfc.nasa.gov/edu/SEES
A Global Land Vegetation Module reviewed by the NASA Earth Science Enterprise Education Product Review Committee is ready for classroom use and can be found on this Web site.
4. Canada Centre for Remote Sensing
http://www.ccrs.nrcan.gc.ca/ccrs/homepg.pl?e
Canada Centre for Remote Sensing Web site lesson: "Watching Over Our Planet From Space. Clearcutting in the Forest." This teacher kit activity can be downloaded cost-free.

This activity is an excellent adjunct to the NASA lesson presented in this video guide segment.

Activity Reading Level: Flesch-Kincaid: 9.0

National Standards (Science Content)
Grades 9-12

Life Science–Content Standard C:
The Interdependence of Organisms
- Organisms both cooperate and compete in ecosystems.
- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption.

Earth and Space Science–Content Standard D:
The Origin and Evolution of the Earth System
- Interactions among the solid Earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the Earth system.

Science and Technology–Content Standard E:
Understandings about Science and Technology
- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.
- Science often advances with the introduction of new technologies.

Science in Personal and Social Perspectives–Content Standard F:
Environmental Quality
- Natural ecosystems provide an array of basic processes that affect humans.

Natural and Human-Induced Hazards
- Normal adjustments of Earth may be hazardous for humans.
- Human activities can enhance potential for hazards.
- Some hazards . . . are rapid and spectacular. But there are slow and progressive changes that also result in problems for individuals and societies.
- Natural and human-induced hazards present the need for humans to assess potential danger and risk.

History and Nature of Science–Content Standard G:
Nature of Scientific Knowledge
- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied.
- Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available.

Additional References

The Deforestation of the Amazon: A Case Study in Understanding Ecosystems and Their Value
http://ublib.buffalo.edu/libraries/projects/cases/amazon.html

Rain Forest Report Card: Deforestation of Tropical Rain Forests
http://www.bsrsi.msu.edu/rfrc/deforestation.html

Rainforest Biodiversity: The Scale of Destruction
http://www.rainforests.net/species2.htm

Ancient Forests Video:
http://www.greenpeaceusa.org/forests/

Slash and Burn Agriculture
http://www.cotf.edu/ete/modules/troppois/tpslashburn.html

Tropical Deforestation Fact Sheet
http://earthobservatory.nasa.gov/Library/Deforestation

Science in the Rainforest: Rainforest Facts
http://www.pbs.org/tal/costa_rica/index.html

Rainforest Treat
http://school.discovery.com/lessonplans/programs/habitats/tropicalrainforest/index.html#activities

Teaching Tropical Rainforest Biology
http://www.accessexcellence.org/21st/TL/sly/

"Focusing Radar's Lens: Remote Sensing Tools Reveal Ecological Secrets," INSIGHTS Magazine, January 1998
http://ct.gsfc.nasa.gov/insights/vol4/radar.htm

Credits

Lynn Birdsong, Ambassador, Maryland Ambassador Program, NASA Goddard Space Flight Center Earth and Space Sciences Education Project, Secondary Science New Teacher Mentor, Howard County (Maryland) Public Schools.
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Eleanor Smith, Ambassador, Maryland Ambassador Program, NASA Goddard Space Flight Center Earth and Space Sciences Education Project, Aerospace Teacher, DuVal High School, Lanham, Maryland.

Mapping the Amazon: Clearcutting in the Forest

Pre-viewing Activities

Question

Would optical photographs be sufficient pictures of the Amazon for the purpose of studying deforestation of the tropical rainforest? Explain.

Vocabulary to Know

Clearcutting
Flood Plain
Landsat
Mosaic
Remote Sensing
Selective Deforestation
Shade Agriculture
Slash and Burn
Wetlands

Video Viewing Questions

1. The Amazon rainforest is the largest ___________ forest in the world.

2. It stretches across __________almost from ocean to _________.

3. NASA began mapping the Amazon from _______.

4. What are two advantages of using satellite pictures to photograph the Amazon area?

5. The Japanese satellite that was used for mapping is called ___________. This stands for _____________________.

6. The satellite collects vast amounts of data. The _________________ crunches the data into images of the Amazon.

7. After the images are created they are layered over one another and adjusted to make large ___________________.

8. These maps are then used to reveal conditions on the ground such as the ______________ and the _______________ of the Amazon River.

9. The largest city along the Amazon River is __________.

10. Landsat is better at telling what type of __________ is growing and what areas of trees have been cleared.

Mapping the Amazon: Clearcutting in the Forest

Activity 2

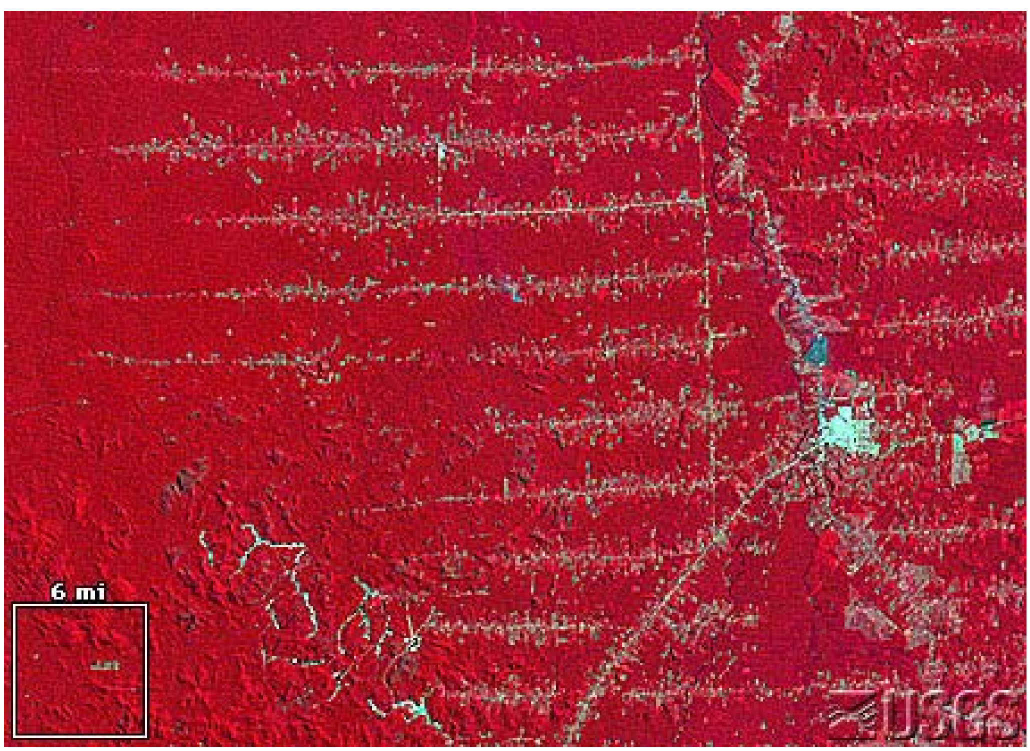
Creating and Using a Dot Grid to Measure and Compare Areas of Satellite Images

1. Select a piece of graph paper and lay a piece of acetate (transparency paper) on top of it.
2. Place an ink dot on the acetate at each point where the graph paper lines intersect. Continue across the acetate until you have at least 20 dots across and 20 rows down. The scale of the graph paper is insignificant, as you will be counting units or dots rather than using a specific scale.
3. Print (in color) satellite images showing Rondônia, Brazil, in 1975, 1986, and 1992 from the following Web site:
http://edcwww.cr.usgs.gov/earthshots/slow/Rondonia/Rondonia
Alternatively, one may make color photocopies of the images included in the printed guide or print the pages from the PDF file.
4. Place the acetate dot grid on top of the 1975 satellite image of Rondônia. First, count all dots that lie within the entire satellite image. Be careful to not move the acetate while you are counting. Next, proceed to count the dots that fall within the areas corresponding to the colors in the key for the Landsat image (found on page 34). If a dot is right on the edge of an area, only count it if it is more than one-half inside the area. Otherwise, it belongs to the adjacent area and would be counted twice. From your count, you will need to discern the percentage of dots (out of the total dots) that represent each land feature.
5. Repeat the above dot calculation activity for the 1986 and 1992 images.
6. Using the scale provided on the image, determine the total area that the image represents.
7. Use the conversion factors for metric/English or customary to calculate how many square kilometers of each type of geographical features (pavement, vegetation, etc.) exist.
8. Construct a line graph to depict your findings.

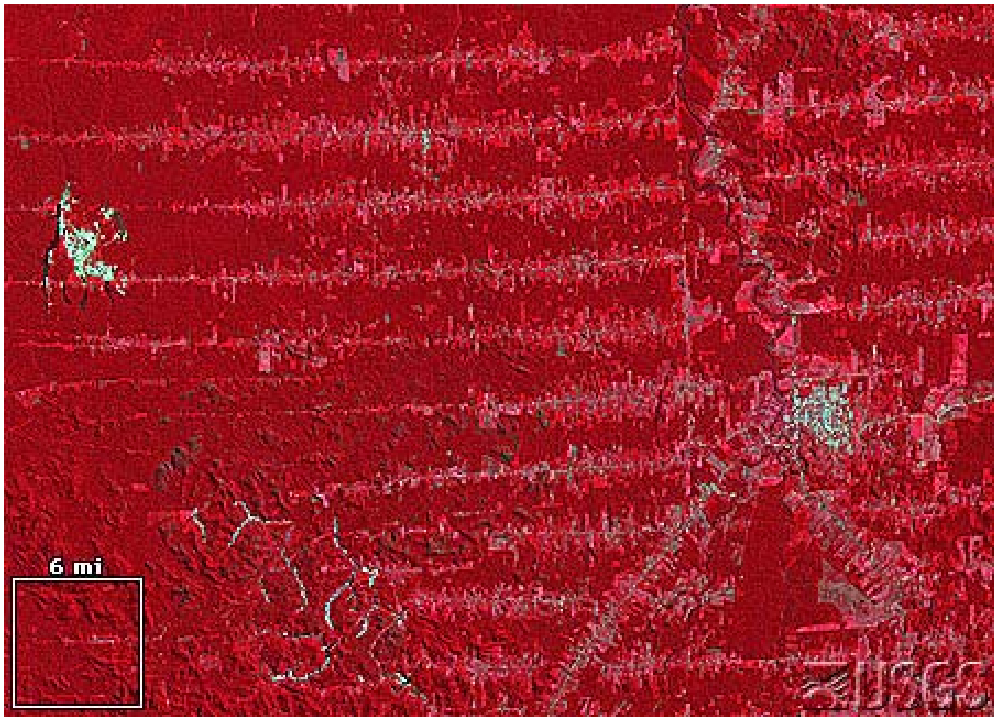
Square Measure:
Square Kilometer = .3861 Square Mile = 100 Hectares = 247.1 Acres
Square Mile = 2.59 Square Kilometers = 259 Hectares = 640 Acres

Analysis Questions:
1. Was there a higher rate of percent change between 1975 and 1986 (11 years) or between 1986 and 1992 (6 years)? What about this fact should be alarming to us, if anything?
2. Should the people of Brazil have the right to deforest their part of the Amazon rainforest in order to decrease their national debt and improve the quality of life for their citizens?
3. Should the international community have any rights to limit deforestation within the countries which "own" the natural resources in the world's rainforests?
4. What is YOUR role in protecting the natural resources in the rainforests?
5. List 10 natural resources that will be lost if we continue to destroy rainforests (i.e., specific endangered plants or animals, etc.).
6. How can deforestation in the rainforests affect climate and weather changes worldwide?
7. How have satellites and supercomputers improved our understanding and monitoring of rainforest destruction and its effects?

Satellite Images of Environmental Change
Source: http://edcwww.cr.usgs.gov/earthshots/slow/Rondonia/Rondonia
Rondônia, Brazil 1975



Satellite Images of Environmental Change
Source: http://edcwww.cr.usgs.gov/earthshots/slow/Rondonia/Rondonia
Rondônia, Brazil 1986



Satellite Images of Environmental Change
Source: http://edcwww.cr.usgs.gov/earthshots/slow/Rondonia/Rondonia
Rondônia, Brazil 1992

KEY
◊ Red = Vegetation
◊ Pink = Grazing Land
◊ Green-yellow = Cropland
◊ Light blue or blue-green = Pavement or bare soil
◊ Dark blue or black = Bodies of water

Rainforest Deforestation Debate Notes Worksheet

IO-ME Lumber Purchasing Team	Save Our Earth Environmental Protection Team
TOTAL=	**TOTAL=**

Write abbreviated cogent and appropriate points made by each team/one per row. At the end you will tally points made for each team.

Mapping the Amazon: Clearcutting in the Forest

Educators' Answer Key

Pre-viewing Activities

Question

As the students have not watched the video yet, it may be useful to prime them by mentioning how big the Amazon rainforest is, which will get them thinking about how difficult it is to photograph an immense area.

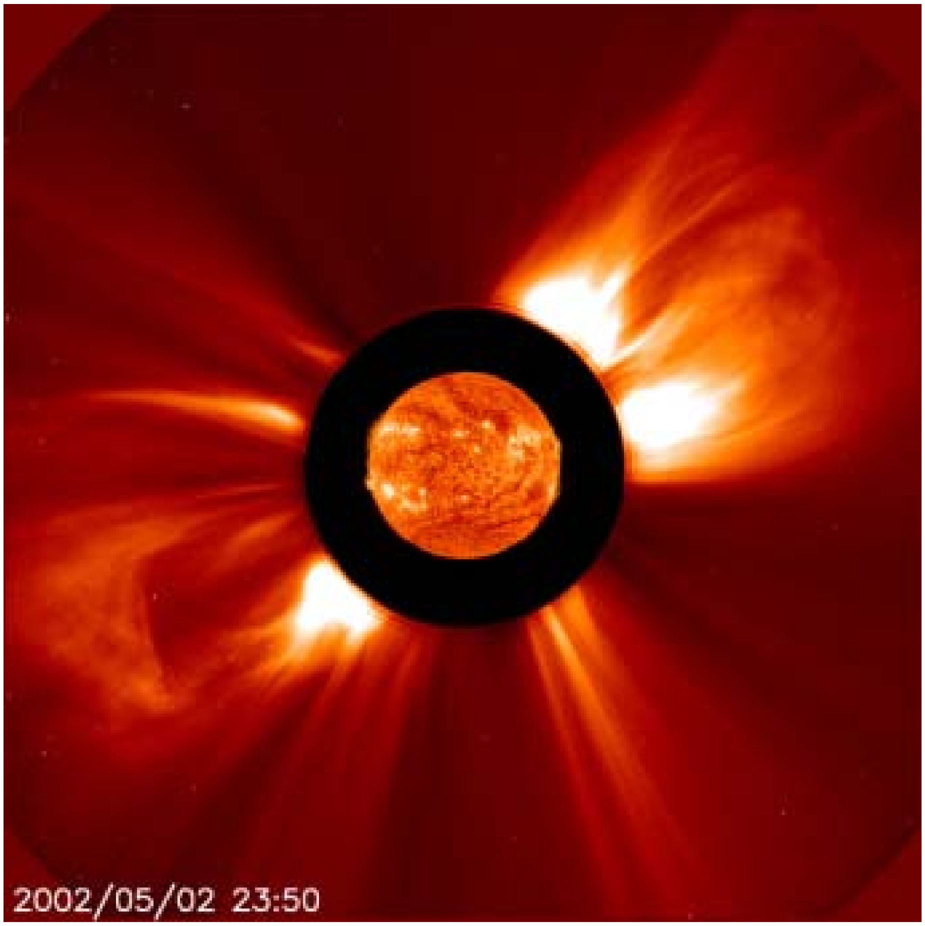
Video Viewing Questions

1. Tropical
2. South America, ocean
3. Space
4. The satellite described in the video can cover the Amazon rain forest in 2 months and penetrate clouds and smoke.
5. SAR, synthetic aperture radar
6. Supercomputer
7. Mosaics
8. Tree-clearing that happened between the low water and high water seasons, changing course
9. Manaus
10. Vegetation

Classroom Activities

The Violent Sun

Double Trouble Solar Bubbles



On May 2, 2002, two enormous clouds of energetic particles blasted away from the solar surface in nearly simultaneous eruptions. Known as coronal mass ejections (CME's), they appear as large "bubbles" oriented at about 2 o'clock and 8 o'clock in this composite image from cameras onboard the Sun-staring SOHO spacecraft.
Source: http://antwrp.gsfc.nasa.gov/apod/ap020516.html

Subjects

Supercomputers, coronal mass ejections (CMEs), corona, solar prominences, magnetic fields, LASCO, SOHO

Background

Scientists believe that coronal mass ejections (CMEs) erupt from the Sun's outer corona as a huge bubble of plasma. The energy supply needed to produce the violent explosion of a CME is believed to come from the Sun's complicated magnetic fields that burst from its interior. Navy scientists are using supercomputers to seek the trigger of these ejections.

The larger and higher magnetic fields are believed to hold down the newer, smaller fields emerging from the surface, restraining the plasma and the magnetic fields trying to rise to the corona. Tremendous energy builds up and as heat is added to the bubble, it begins to accelerate, soon escaping the Sun's gravitational field.

A CME speeds across space at great velocities, carrying a 10 billion-ton bubble of plasma into the solar system. The energy in this bubble of plasma is comparable to the energy combined in 100 hurricanes.

As the CME plows through space, it creates a shock wave that accelerates particles to dangerously high speeds, bombarding planets, asteroids, and other objects with radiation and plasma. If the CME erupts on the side of the Sun facing the Earth, and our orbit intersects the path of the plasma cloud, the results can be both spectacular (auroras) and dangerous to some of our modern technologies.

When a CME dumps 1,500 gigawatts of electricity (double the electric generating power of the entire United States) into the atmosphere, big changes occur that can wreak havoc on satellites. As a society we have come to depend on satellites, electrical power, and radio communication–all of which are affected by these electric and magnetic forces. Since so much information is relayed by satellites–from ATM machines and broadcast signals to disaster warning systems–CMEs pose a technological hazard to our civilization.

Prior to viewing "Journeys through Earth and Space," The Violent Sun, students should be familiar with:

- General structure of the Sun
- Sunspots (and sunspot cycle) and prominences
- Magnetism and magnetic fields

Lesson Plan

Objectives:
Students will

Recall, from the video, the mechanism for triggering coronal mass ejections. Describe an event in which an Earth-orbiting satellite was affected by solar activity. List some other effects at Earth of space weather. Visit Internet sites to gain information and understanding to learn why coronal mass ejections occur and the impact they have on satellites above the Earth's atmosphere. Model magnetic fields found on the Sun's surface.

Engage:
1. Activity 1: Space Weather's Impact on Earth
Students recall or research a recent event in which a satellite was affected by solar activity.

Although references are provided, students are encouraged to independently search the Internet or other references to locate a solar event that adversely affected an Earth-orbiting satellite.

References:

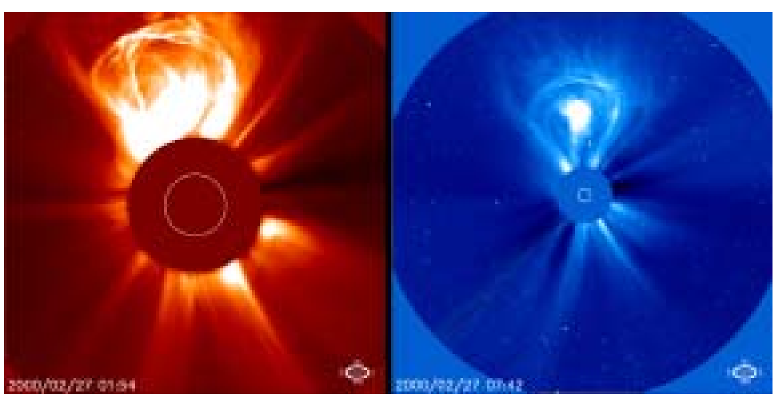
- Effects of Space Weather Events
  http://www.windows.ucar.edu/spaceweather/spweather_5.html
- Telstar 401
  http://www.cnn.com/TECH/9701/20/cosmic.rays/
- The Anik Panic
  http://www.windows.ucar.edu/spaceweather/anik.html

Questions to explore and discuss:

- Describe the circumstances of the event.
- When did it occur?
- What satellite was involved?
- What was the damage to the satellite?
- What was the economic impact?
- Identify ways in which scientists may protect satellites from damage from solar events.

The teacher may conduct a discussion to determine unique and common factors to the events found by the students. A chart may be helpful to compare and contrast the student responses.

2. Video Activities
Have students complete the Pre-viewing Activities.
Show the video "Journeys through Earth and Space," The Violent Sun. Students will complete the Video Viewing Questions. Discuss answers to the Viewing Questions.



"Lightbulb" CME. A coronal mass ejection on Feb. 27, 2000, taken by LASCO C2 and C3. A CME blasts into space 1 billion tons of particles traveling millions of miles an hour. This particular CME is "lightbulb-shaped."
Source: http://sohowww.nascom.nasa.gov/bestofsoho/PAGE3/

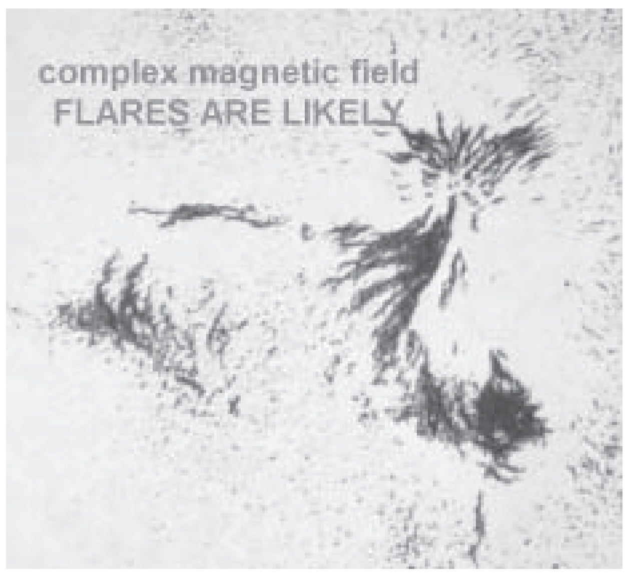
Students should visit the following Web sites and perform the activity or activities.

Explore:
Activity 2A
Coronal Mass Ejections: Satellites in Peril
http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/cme.abstract.html

Explain:
Activity 2B
Coronal Mass Ejections & Their Effect on Earth – A Student Activity
http://www-istp.gsfc.nasa.gov/istp/nicky/cme-activity.html

The following investigations are supplementary and will augment learning about the release of CMEs from the Sun.

Extend:
1. Supplementary Activity 1: Sunspot Twister



Students visit the following Web site and perform the investigation:
Sunspot Twister
http://www.thursdaysclassroom.com/12jun01/teach7.html

2. Supplementary Activity 2: Solar Rubber Bands

Students visit the following Web site and perform the investigation:

Solar Rubber Bands
http://www.thursdaysclassroom.com/12jun01/activity2.html

Refer to http://www.spacescience.com/headlines/y2000/ast05apr_1m.htm for information about solar magnetic fields and their measurement.

Evaluate:
Journal Write
Students should compose an essay that summarizes their learning about the Sun's effect on Earth's environment. Topics should include:

Sunspots	Aurorae
Solar Flares	Magnetic Fields
Coronal Mass Ejections	Magnetosphere

Activity Reading Level: Flesch-Kincaid: 8.5

National Standards (Science Content)
Grades 9-12

Science as Inquiry–Content Standard A:
Abilities Necessary to Do Scientific Inquiry
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.

Physical Science–Content Standard B:
Motion and Forces
- Between any two charged particles, electric force is vastly greater than the gravitational force.
- Objects change their motion only when a net force is applied.

Science and Technology–Content Standard E:
Abilities of Technological Design
- Identify a problem or design an opportunity.}

Additional References

Solar Physics Homepage, NASA Marshall Space Flight Center
http://science.msfc.nasa.gov/ssl/pad/solar/the_key.htm

SOHO Homepage, NASA Goddard Space Flight Center
http://sohowww.nascom.nasa.gov/
A good source of lesson plans about the sun and solar physics.

Coronal Mass Ejections, Solar Flares, and the Sun-Earth Connection
http://hesperia.gsfc.nasa.gov/sftheory/cme.htm

Coronal Mass Ejections
http://science.msfc.nasa.gov/ssl/pad/solar/cmes.htm

The Sun-Earth Connection Education Forum
http://sunearth.gsfc.nasa.gov

It Takes a Telescope and a Microscope, INSIGHTS Magazine, April 2000
http://ct.gsfc.nasa.gov/insights/vol13/tele.htm

Credits

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The Violent Sun

Pre-viewing Activities

Question

What are some ways in which the Sun is harmful to humans and Earth?

Vocabulary to Know

Corona
Coronal Mass Ejection (CME)
Plasma
Prominence

Video Viewing Questions

1. The Sun is not only a life giver, but also a ______________________.

2. The most deadly solar storms are ____________________.

3. The corona is the Sun's ___________________.

4. Most CMEs start out as ____________________.

5. Prominences are arches of ________ that rise above the _________________.

6. How do solar prominences compare to the atmosphere around them? _____________ __________________________________.

7. Scientists believe that ________________ suspend prominences above the Sun's surface.

8. In simulating the escape mechanism of these eruptions, scientists crashed the computers. How does the PARAMESH software tackle this problem? ___________________ ___________________________.

9. Two things scientists are hoping to learn from computer calculations are:
a. _________________ and
b. _________________.

The Violent Sun

Educators' Answer Key

Pre-viewing Activities

Question

Some everyday examples include sunburn from prolonged exposure, sunlight making it difficult to see when driving, and parked cars being heated to temperatures that are dangerous to children and pets. An effective introduction to the video story might include mentioning that the Sun can also be dangerous to the satellites that broadcast television and other services to the world.

Video Viewing Questions

1. Destroyer
2. Coronal mass ejections
3. Outer atmosphere
4. Prominences
5. Gas, Sun's surface
6. Prominences are very cold and very dense.
7. Magnetic fields
8. PARAMESH targets a simulation's mesh or grid where things are changing.
9. Several hours' warning before a CME erupts, a very accurate characterization of the CME as it moves towards the Earth

Transcript

Introduction

Narrator: Why are the Rocky Mountains so far inland?

How do we preserve the changing Amazon rainforest?

When will the Sun fling parts of itself towards Earth?

NASA is tackling questions like these inside supercomputers. Here, billions of calculations per second recreate the universe mathematically.

Supercomputers can process observations into a motion picture.

Or, they can solve equations that describe realities seen and unseen.

Whatever the technique, supercomputers advance NASA's mission as much as its space telescopes or Earth-watching satellites.

To understand and predict nature through computation, NASA started the Earth and Space Sciences, or ESS, Project.

ESS researchers are building software to travel from the core of the Earth to the edge of the cosmos.

We join three teams on their journeys to discovery.

A Rocky Paradox

"The glades which begin so softly are soon lost in the dark primeval forests, with their peaks of rosy granite, and their stretches of granite blocks piled and poised by nature in some mood of fury."

–Isabella L. Bird

Scientists:
Hans-Peter (Peter) Bunge, assistant professor of geophysics, Princeton University;
John Baumgardner, geophysicist, Los Alamos National Laboratory

Narrator: The Earth's solid surface was born deep inside the planet. Like other mountains, the Rockies of western North America sprang from a region called the mantle.

Peter Bunge: The mantle is, if you will, just another ocean inside of the Earth.

Narrator: In this middle layer, rock can flow while remaining solid because of extreme pressures and temperatures. Rock cools off at the top of the mantle and forms tectonic plates. Over the ages these slabs shape the Earth we know.

A supercomputer is a time machine. With the TERRA software, scientists can visit the geological past and make it come alive.

John Baumgardner: TERRA is an Earth simulator that we can run on a computer to simulate what goes on inside the Earth. The processes by which the rock flows to cause the plates to move across the Earth surface, to cause mountains to be formed, to cause new ocean basins to open. It's able to model these large-scale processes that involve the Earth's interior.

Narrator: At Princeton, Peter Bunge found a new task for TERRA: learning why the Rocky Mountains have a unique location.

Peter Bunge: The Rockies are funny in a sense that they are a mountain range that is really fairly far away from any active plate boundary.

Narrator: Indeed, the Rockies are fifteen hundred kilometers, or one thousand miles, to the east. The cause must be the tectonic plate that built these mountains. Its name is Farallon.

Farallon was one of several oceanic plates that plunged beneath western North America and then sank into the mantle. This sinking dramatically affected the surface geology.

Farallon vanished into the mantle long ago. But by studying how sound waves travel through the planet after earthquakes, seismologists found the plate lying under the East Coast of the United States.

Peter Bunge: In fact, I consider it really as one of the major triumphs in seismology, to have us shown in such great detail an oceanic plate that is entirely now inside of the Earth's interior, showing it to us all the way from the bottom of the mantle, three thousand kilometers below our feet.

Narrator: Bunge mounted a simulation to see what process could have gotten the Farallon Plate to its current location. The option that worked had the plate undergo some strange behavior.

Farallon started off normally enough. It plunged beneath the North American Plate at a forty-five degree angle. This process sprouted volcanoes to form the Sierra Nevada in what is now California.

Next, mantle motions pulled North America westward over Farallon, and the plate scraped along the bottom of the continent–for fifteen hundred kilometers. As North America continued its westward trek, Farallon settled to the bottom of the mantle.

Crust that had accumulated above the sinking plate then bobbed up like a cork to form the Rocky Mountains.

John Baumgardner: There was also a significant burst of volcanic activity about the time this plate disappeared and sank. The main explosive event, actually it is believed there were two large events, these two large events together erupted enough volcanic ash to cover the whole state of New Mexico between three and six feet deep–just a staggering amount of volcanic ash produced, something like five hundred times more ash than was erupted in Mt. St. Helens.

And it produced a caldera. The original peak of the mountain then collapsed down into the caldera. The caldera itself is about fifteen miles across or about twenty-five kilometers across. We're talking about volcanism on a scale that we've not seen in historical times. It just boggles the human mind to imagine an event of that magnitude.

Mapping the Amazon

"The clearest way into the universe is through a forest wilderness."

–John Muir

Scientists:
Paul Siqueira, staff scientist, NASA Jet Propulsion Laboratory;
Dave Curkendall, manager, Advanced Parallel Processing Program, NASA Jet Propulsion Laboratory;
Laura Hess, postgraduate researcher, Institute for Computational Earth System Science, University of California, Santa Barbara

Narrator: The Amazon rainforest is the largest tropical forest in the world. It stretches across South America from nearly ocean to ocean. No seasonal view of this territory existed until a NASA-university collaboration began mapping the Amazon–from space.

Paul Siqueira: If you were to take a picture of this with an optical photograph, it would take about 10 years to actually get an entire picture of the Amazon put together. And even then, the Amazon is continuously changing, and so it's very difficult to get an idea of what's going on, on the ground.

Narrator: A satellite can cover the Amazon in just 2 months. The mapping team chose a Japanese satellite outfitted with synthetic aperture radar, or SAR for short.

SAR is a natural fit for the Amazon. It can penetrate the clouds that pour rain for half of the year and the smoke from trees burned by farmers to clear land. SAR even works at night.

As you might imagine, the satellite collects piles of data. In raw form, these observations are gibberish. Focusing them requires a supercomputer to crunch fifteen hundred trillion calculations. The output is rich images of the Amazon.

Dave Curkendall: After the images are created, they are brought here to the Jet Propulsion Laboratory, and they are assimilated into the large mosaics really by carefully taking individual pictures and laying them over one another so, and looking very carefully at the overlap and adjusting where one picture is relative to the other one, until the overlap on the two scenes are absolutely coincident. And rather than do that scene by scene, what we really do is take fifteen hundred of those scenes, drive stakes into the whole assemblage where we know exactly where a feature that is visible in one of the images is an exact latitude and longitude, and then produce a global fit that encompasses the whole continent.

Narrator: Curkendall's team uses graphics supercomputers to assemble and display the Amazon mosaic. On a wall-sized screen, they can pan across the region or zoom down into any location. The mosaic combines the low water season of 1995, colored blue, and the high water season of 1996, colored yellow. Together, these snapshots reveal conditions on the ground.

One feature that shows up is tree-clearing that happened between the two seasons.

The mosaic also captures the changing course of the Amazon River itself.

Laura Hess: The Amazon River is the highway of the Amazon and always has been. It's the main road of human settlement, and it's the first area that was settled in the Amazon. All the major cities in the Amazon are located on the river itself or on its main tributaries.

Narrator: The largest city along the Amazon River is Manaus. NASA's mosaic says that thirty percent of the surrounding area is wetlands. Global warming forecasters need to get the figure right, because plants in standing water emit the greenhouse gas methane.

Wetlands contain a variety of vegetation, as does the Amazon on the whole. To supplement the mosaic with details about vegetation types, university researchers took video footage from the air.

Laura Hess: So with these surveys we could see from the video what the conditions were like at high water stage and at low water stage. And on the Amazon flood plain that's a difference of ten meters, about thirty feet, in the flood stage. So that's enough of a difference that actually trees could be completely covered between low water and high water. We have a very different landscape, and it's going to appear very different on the radar mosaic. So if we're going to classify the radar mosaic using image-processing techniques, we have to really understand what those environments are on the ground in order to get a correct classification.

Narrator: Special equipment puts latitude and longitude information onto the video. Hess compares it with the mosaic so that geographic points match the real world.

The Amazon team is putting their images on the World Wide Web and CD-ROMs. Among other benefits, this information is guiding people who live and work in the rainforest.

Paul Siqueira: An interesting application of what we've done, this data has actually been used by the Brazilian petroleum industry and what they are trying to do is, they'd like to tap the petrol reserves that are in the Amazon. And this could actually be quite useful for the country economically because they would be able to exploit the Amazon without actually destroying the trees.

Narrator: While SAR and aerial video uncover many of the Amazon's secrets, Dave Curkendall wants to learn more. He envisions adding the perspective of the Landsat satellite, which photographs the world in visible light.

Dave Curkendall: The Landsat, which already is a multispectral instrument, is probably better in some circumstances at telling whether a certain patch of ground contains vegetation and what that vegetation might be. Knowing that it is vegetation and what kind it is, the radar is also good at telling more about the density of that type of vegetation.

The Violent Sun

"The Sun, with all the planets revolving around it, and depending on it, can still ripen a bunch of grapes as though it had nothing else in the universe to do."

–Galileo Galilei

Scientists:
Spiro Antiochos, solar physicist, Naval Research Laboratory;
C. Richard (Rick) DeVore, physicist, Naval Research Laboratory;
Peter MacNeice, computational scientist, NASA Goddard Space Flight Center

Narrator: The Sun is a life-giver. It bathes our planet in light and energy.

As we have recently learned, the Sun is also a destroyer. Solar storms that hit Earth's atmosphere just right can knock out satellites or power grids.

The most deadly of these storms are coronal mass ejections.

Spiro Antiochos: The corona is the Sun's outer atmosphere, and a large chunk of mass up to a billion tons comes out with over a million miles an hour. Actually here at the Naval Research Lab when we describe it to the admirals, in order to get their attention, we say it's one hundred thousand Nimitz-class aircraft carriers steaming out at a million knots.

Narrator: With supercomputers, Navy scientists are seeking what triggers the ejections.

Most coronal mass ejections, or CMEs, start out as prominences. These arches of gas rise above the Sun's surface.

Rick DeVore: The observations tell us that prominences are very cold and very dense structures compared to the atmosphere that surrounds them, which tends to be rather hot and rather low-density. And this raises the puzzling question, and the technical challenge, of how to form these prominences and keep them suspended above the surface. We believe that magnetic fields create that support.

Narrator: Telescopes can't see those magnetic fields, so scientists have to simulate them. The Navy team starts by stretching loops of magnetic field.

Rick DeVore: And what we find is that as magnetic field underneath the loop is stretched out lengthwise, quite a distance from the loop center, we find that the center portions of our stretched field lines dip. This forms the magnetic hammock which is capable of supporting the prominence plasma against gravity.

Narrator: Further stretching the field lines causes them to snap apart and connect to other field lines. The Navy researchers believe a frenzy of this reconnection triggers the prominence to erupt as a CME.

Spiro Antiochos: Think of the low-lying fields as let's say a helium balloon. They want to expand outwards; they are naturally very buoyant. They want to expand outwards, but overlying them are other magnetic fields. They are older magnetic fields that have been in the Sun's atmosphere for some time, and those magnetic fields, they act like bungee chords holding down this helium balloon. The trick now is to remove these overlying fields very rapidly, have some mechanism to let the underlying field escape.

Narrator: Attempts to simulate that escape mechanism crashed the supercomputer, which couldn't focus on the whole Sun and the small region where field lines are breaking at the same time.

NASA offered a solution in PARAMESH. This software targets a simulation's mesh or grid where things are changing.

Peter MacNeice: The best analogy is to soldiers on a battlefield. The general could distribute them uniformly across the battlefront, but that's not a terribly smart strategy. Instead he focuses soldiers into groups where their efforts are most needed. PARAMESH does that with the basic grid that modelers use to simulate events like this. It focuses the grid points where they are most needed.

Narrator: Earlier, PARAMESH helped show how matter condenses to form a prominence. For CME simulations, the magnetic field lines are where they belong but do not yet reconnect so mass can escape.

As the collaborators close in on the CME trigger, they envision predicting ejections before they happen. That would be a big advance on today's techniques.

Currently, scientists watch the Sun for CMEs heading our way. A few days before arrival, computers calculate where the storms will hit.

Narrator: Forecasting damage is trickier. The satellite trained to catch high-energy particles gives but 1 hour's warning. Companies and space agencies need to protect their assets. Later this decade, a fleet of new satellites will capture changes in the Sun almost as soon as they happen. The data will feed into the Navy's simulations.

Spiro Antiochos: So the two things we're hoping to get from our calculations, and from PARAMESH, are one, several hours' warning before eruption, but also a very accurate characterization of the CME as it propagates to the Earth, and therefore a very accurate prediction as to how geo-effective the CME will be when it hits the Earth.

Science Update

Since completion of this video magazine, Antiochos, DeVore, and MacNeice have successfully demonstrated that reconnection can open magnetic field lines so mass can escape the Sun as a CME. At this point, the scientists are using an idealized model, which they will develop further. Images and movies showing their latest advance are at:

http://ct.gsfc.nasa.gov/macneice/cme.html

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Journeys through Earth and Space
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